EXAMINING MANNING RELATIONSHIPS BETWEEN US AIR FORCE ENTERPRISES AND CAREER FIELDS

A US Air Force (USAF) dataset containing 6 attributes and over 400,000 funded authorizations (paid workforce positions) is analyzed for significant manning relationships among 12 Service Core Functions (SCFs) and 32 functional areas. The authorizations are collapsed into 375 groups of 32 functional equities ranging from Acquisitions to Weather career fields. The SCFs are managed by 7 Core Function Leads (CFLs) who are typically Major Command (MAJCOM) commanders. Logistic fit analyses via logistic odds ratio (OR) comparisons and contingency table analyses reveal significant manning shortfalls in all 12 CFLs. The results of the analysis hope to better inform the USAF Strategic, Planning & Programming Process (SP3). The SP3 is a Chief of Staff of the Air Force (CSAF)-approved framework that guides strategic decision making.

Keywords: Logistic Regression, Personnel risk, Relative Risk, Strategic risk, Odds Ratio

Introduction

The primary objective of this cross-sectional observational study is to examine ways to assess manning data that may help senior Air Force leaders manage personnel capability and enhance maximization of readiness.   The desired endstate is a more defensible, rigorous methodology to better inform SCF (**Figure 1**) strategic risk assessments. This would enable SCF personnel planners to assess manning shortages to more accurately inform the USAF budget, thereby, enabling the CSAF to better manage personnel combat capability. Manning is defined as the ratio of the number of personnel and the number of funded authorizations:

$$Manning \ = \frac{Number \ of \ (assigned) \ personnel}{Number \ of \ funded \ authorizations}.$$

Each USAF unit has a unit manning document (UMD) which stipulates the number of personnel and funded authorizations. Each authorization represents a funded position. Ideally, funded authorizations should have assigned, trained personnel filling the positions, but this is usually not achieved across the USAF.

Air Force Core Functions

Nuclear Deterrence Ops	Global Precision Attack
Air Superiority	Special Operations
Space Superiority	Rapid Global Mobility
Cyberspace Superiority	Personnel Recovery
Command and Control	Agile Combat Support
Global Integrated ISR	~~Building Partnerships~~

Personnel & Training

Figure 1: USAF Service Core Functions (SP3 2011)

Career fields are often undermanned, which results in a stressed, overworked workforce that equates to increased military risk. As of July 2016, there were over 400,000 active duty military and civil servants in the USAF. Of the 400,000+ personnel, 55% are enlisted, 13% are officer and the remaining 32% are civil servants (See **Appendix II**). The USAF has over 300 career field specialties or Air Force Specialties (AFS). AFSs are further compartmentalized into Air Force

Specialty Codes or AFSCs. The AFSCs are condensed into 32 functional equities (FEs) across the 12 SCFs. A mapping of the career fields to the functional equities is provided in **Figure 2**.
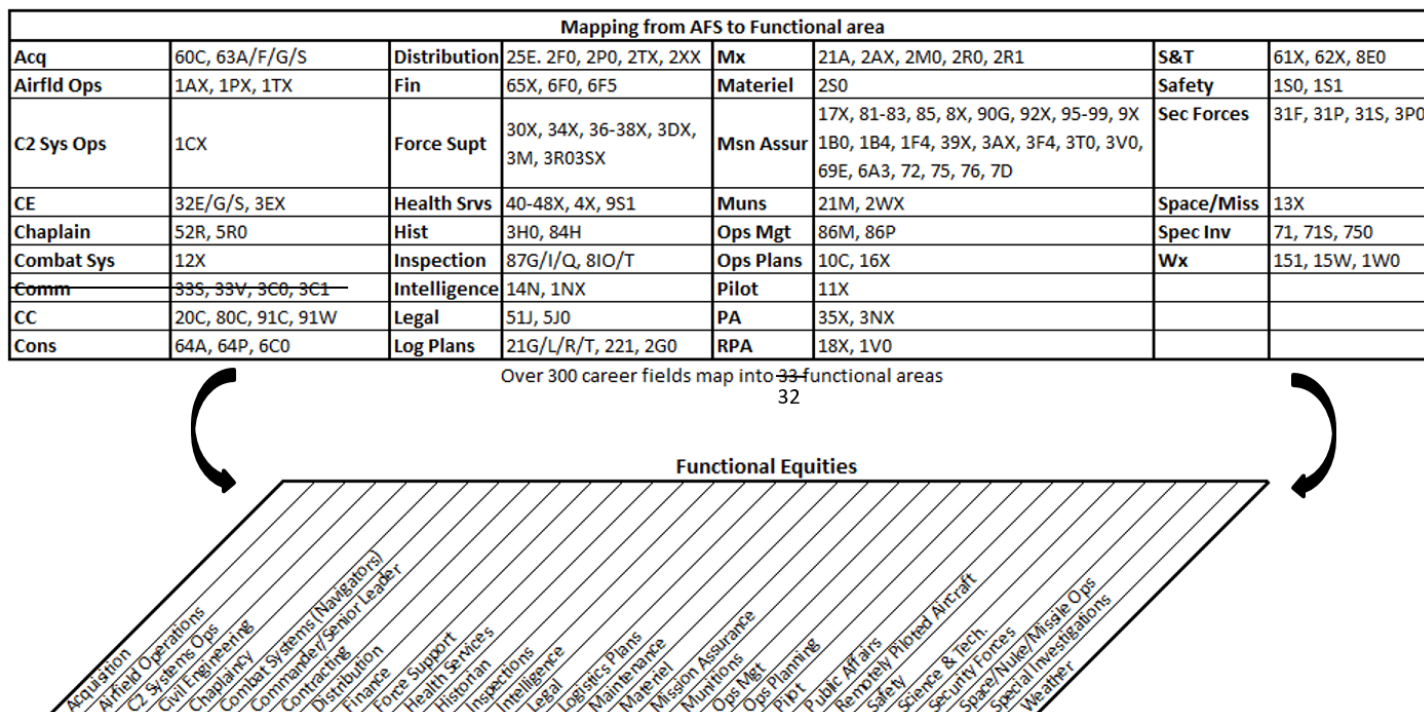
Mapping from AFS to Functional area							
Acq	60C, 63A/F/G/S	Distribution	25E. 2F0, 2P0, 2TX, 2XX	Mx	21A, 2AX, 2M0, 2R0, 2R1	S&T	61X, 62X, 8E0
Airfld Ops	1AX, 1PX, 1TX	Fin	65X, 6F0, 6F5	Materiel	2S0	Safety	1S0, 1S1
C2 Sys Ops	1CX	Force Supt	30X, 34X, 36-38X, 3DX, 3M, 3R03SX	Msn Assur	17X, 81-83, 85, 8X, 90G, 92X, 95-99, 9X 1B0, 1B4, 1F4, 39X, 3AX, 3F4, 3T0, 3V0, 69E, 6A3, 72, 75, 76, 7D	Sec Forces	31F, 31P, 31S, 3P0
CE	32E/G/S, 3EX	Health Srvs	40-48X, 4X, 9S1	Muns	21M, 2WX	Space/Miss	13X
Chaplain	52R, 5R0	Hist	3H0, 84H	Ops Mgt	86M, 86P	Spec Inv	71, 71S, 750
Combat Sys	12X	Inspection	87G/I/Q, 8IO/T	Ops Plans	10C, 16X	Wx	151, 15W, 1W0
~~Comm~~	~~33S, 33V, 3C0, 3C1~~	Intelligence	14N, 1NX	Pilot	11X		
CC	20C, 80C, 91C, 91W	Legal	51J, 5J0	PA	35X, 3NX		
Cons	64A, 64P, 6C0	Log Plans	21G/L/R/T, 221, 2G0	RPA	18X, 1V0		

Over 300 career fields map into ~~33~~ functional areas
32

Figure 2: Functional Equity Mapping

This results in a dataset of 375 observations[1].   **Figure 3** is a bi-chart which shows the assigned USAF personnel by the 12 SCFs along with associated manning rates. **Figure 4** shows manning rates by FE. The mean and median are the same for the FEs. The SCFs are unequally weighted (i.e. the amount of personnel differs by the SCF). Each of the twelve SCFs are supported by Core Function Support Plans (CFSPs) and developed and approved by one of the seven CFLs. CFSPs translate the vision for the specific CFs into risk-informed, resource-constrained, planning force proposals that guide follow-on Program Objective Memorandum (POM) and Science & Technology (S&T) decisions and activities (NAP, 2014).

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[1] The reader should be advised not all 32 functional equities are represented in every SCF, so although 32 x 12 is 384, there are actually only 375 observations.
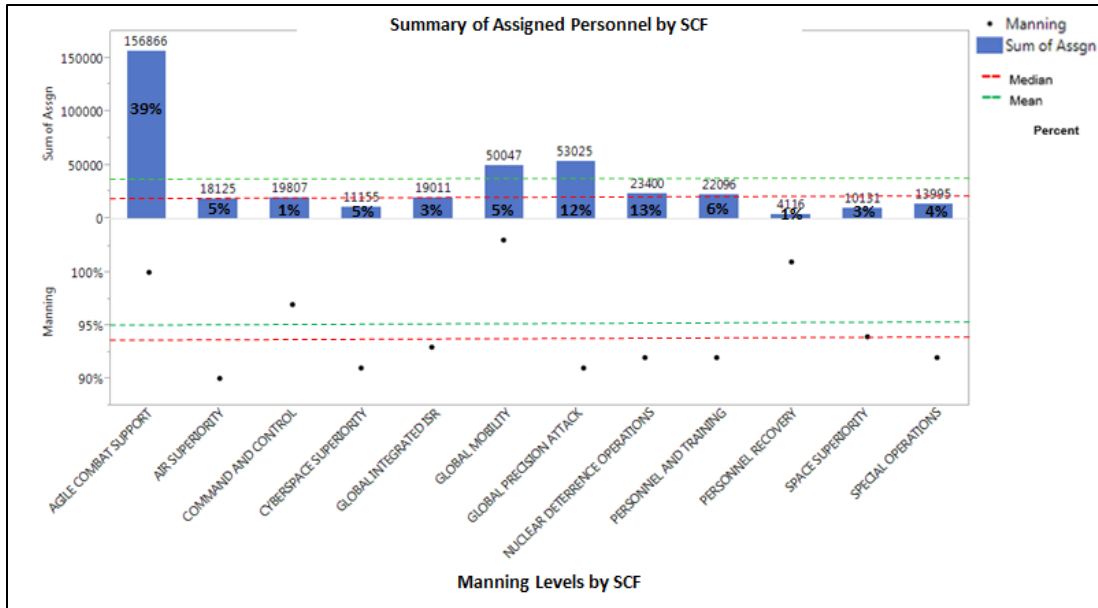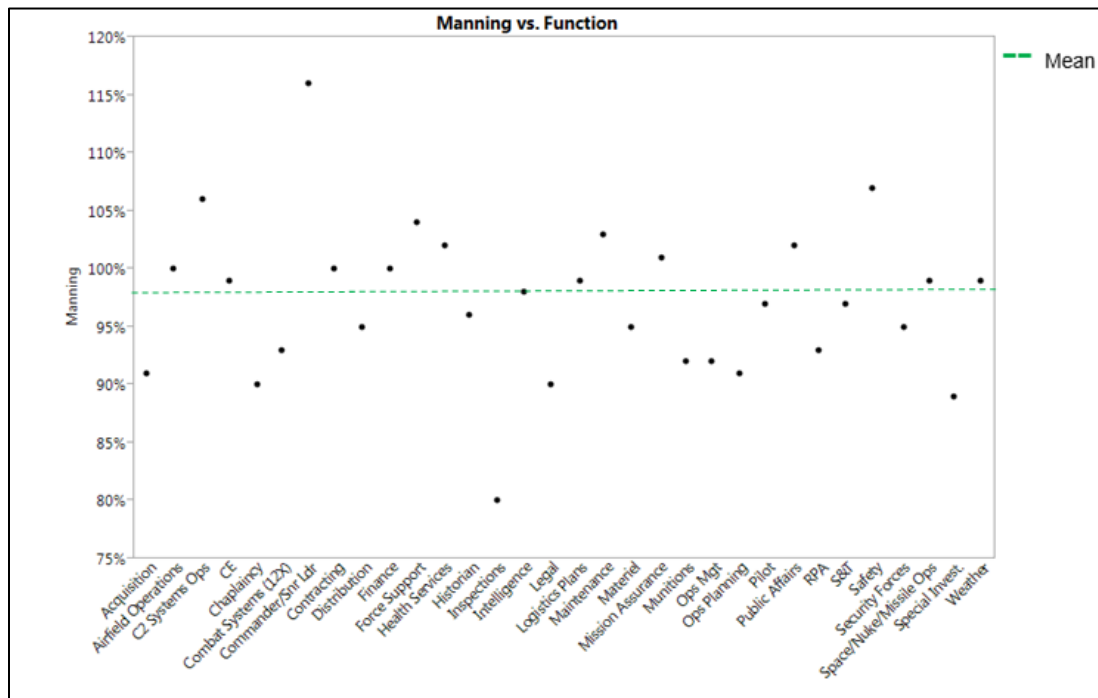
Figure 3: USAF SCF Manning Summary

Figure 4: USAF Functional Equity Manning Summary

Data Overview

This study consists of over 416,485 authorizations collapsed into 375 subsets as of July of 2016 from the Air Force Manpower, Personnel and Services database. Each subset represents a group of FE by SCF. Each observation contains 6 variables listed in Table 1. The variable type characteristics are categorical (to include nominal and ordinal) and numeric.

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Table 1: Variables for categorical analysis

Name	Description and effect type	Type	Levels and notes
SCF	Service Core Function (Fixed)	Nom.	There are 12 USAF SCFs.
Functional Equity (FE)	Career Field Family (Fixed)	Nom.	There are 32 FEs.
Manning category	Binned manning categories between $\geq 100\%$ and $< 80\%$ (Fixed)	Ord.	6 ordered categories
Manning rate	Assigned personnel vs Authorizations (Used to determine 'Fully Manned' & 'Manning category')	Cont.	This is a continuous value.
Fully Manned (Y/N)	Factor which consists of (Fixed) either fully manned or not	Nom.	Binomial variable (outcome)
Overage/Shortage (-)	Number of surplus/shortage of authorizations (Fixed)	Disc.	This is a discrete value.

Research Question & Application of Techniques

In the world of doing either the same amount of workload or less workload with fewer resources, how does one effectively manage resources with respect to assessing personnel capability? In the past, USAF has developed numerous MAJCOM manpower assessments using various techniques. However, since 2010, the USAF has adopted a broader enterprise-level approach via the SCF. A SCF may utilize several MAJCOMs in order to execute its mission. One enduring challenge is accurately assessing personnel deficiencies across the USAF by SCF. If planners could more accurately assess and identify the personnel SCF sight picture, this would help substantiate the risk associated with a lack of required manpower to deliver wartime and peacetime capability. A valid manning assessment can help identify capability gaps and serve as a good planning tool as a means of validating risk. This further enables senior leaders to qualify risk with analysis and increase the odds of filling or mitigating personnel capability gaps. The improved strategic manning assessment could then be used to improve the strategic planning & programming process and enable the CSAF to better advocate for personnel resources. The subsequent research questions and hypothesis ($\alpha = 0.05$) are as follows:

• Is there a meaningful manning relationship between USAF SCFs and full manning levels?
Null Hypothesis (H_0): There is an association between SCF and Full manning levels.
Alternate Hypothesis (H_A): There is no association between SCF and Full manning levels.

• Given, SCFs are unique: is there a rigorous way to compare manning levels among SCFs and FEs?

USAF manning levels typically do not vary much during non-presidential election years and historically, attempts at trying to predict manning beyond a given Fiscal Year Defense Plan (FYDP) have been mostly fruitless. The goal of this study is not to develop a model to predict future manning levels. The goal of this study is to build a SCF and FE comparative manning assessment that strategic leaders can utilize for personnel capability advocacy. Techniques explored will focus on logistic analysis in the form of contingency tables, logistic odd ratios and other methods to compare the SCFs and FEs against the manning levels.

Exploratory Analyses

The next portion uses descriptive statistics to examine if the 12 SCF populations that consist of primarily 32 functional equities are statistically similar. The analysis is performed using JMP 11 Pro. The study uses a significance level (also known as α) of 0.05 or simply there is a 5% likelihood of committing a Type I error (rejecting the null hypothesis, when it is true). **Figure 5** provides standard box and whisker plots by SCF population size intersected by a grand mean; lists the respective SCF standard deviations; and shows a Tukey test pairwise comparison among the SCF means. The plots show evidence of SCF dissimilarity. The standard deviation range among the SCFs is relatively large. The majority of the Tukey test results reveal the SCFs are statistically dissimilar.

ACS – Agile Combat Support
AS – Air Superiority
C2 – Command & Control
CS – Cyberspace Superiority
GISR – Global ISR
GM – Global Mobility
GPA – Global Precision Attack
NDO – Nuclear Deterrence Ops
P & T – Personnel & Training
PR – Personnel Recovery
SO – Special Ops
SS – Space Superiority

- Std dev manning range: 4% – 12.5% (i.e. large)

Connecting Letters Report

Level										Mean
GM	A									1.0309718
PR		B								1.0051307
ACS			C							0.9997451
C2				D						0.9668473
SS					E					0.9365637
GISR						F				0.9331010
SO							G			0.9235850
P & T							G			0.9232152
NDO								H		0.9181729
GPA									I	0.9088182
CS									I	0.9071678
AS									J	0.8971833

Levels not connected by same letter are significantly different.

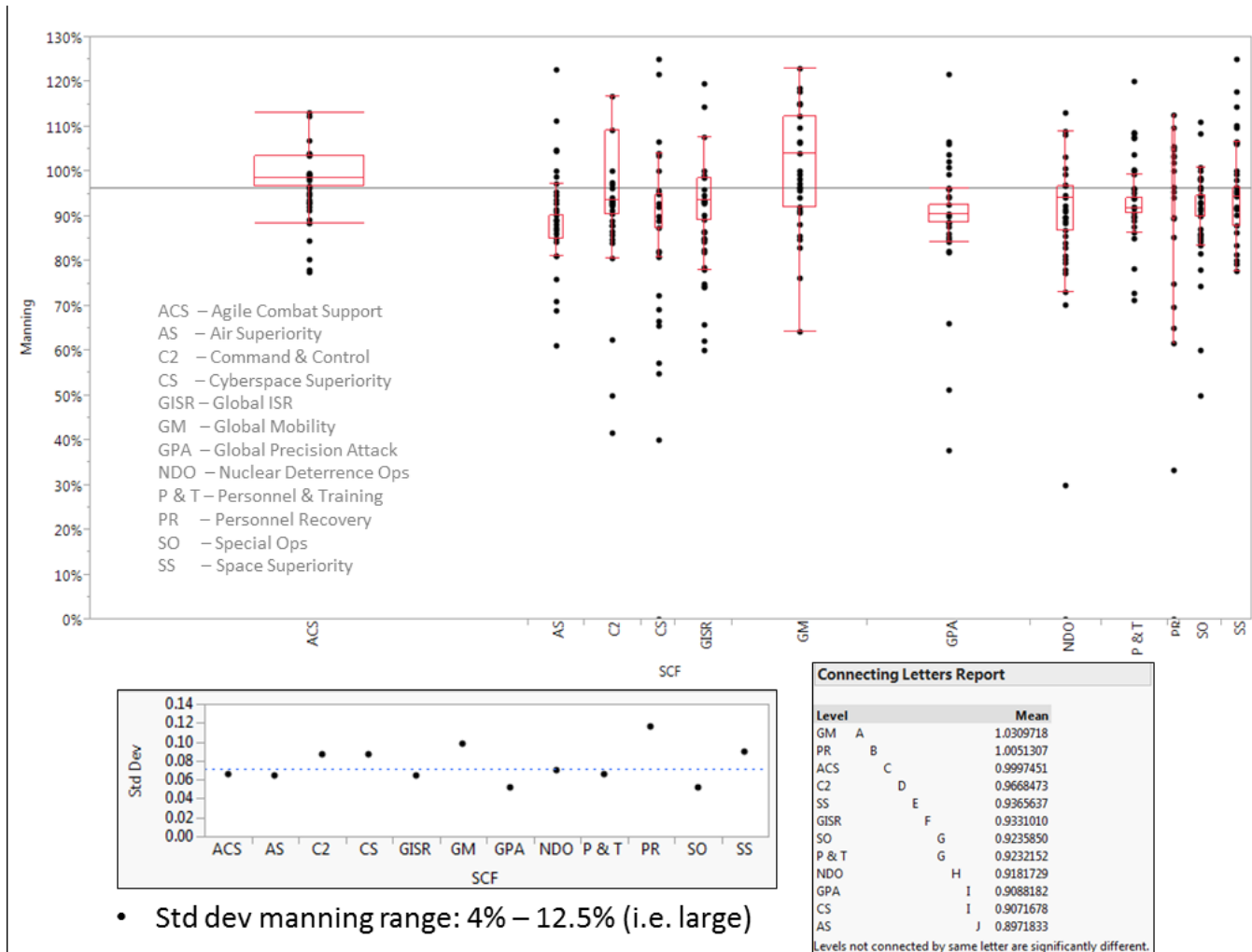**Figure 5:** Descriptive Statistics of SCF Manning Levels

Contingency Analyses

The main outcome variable or response is a binary categorical variable (i.e. ≥ 100% manned or not) and the other factors are fixed nominal and ordinal variables. We use contingency analysis to examine if there are meaningful associations between SCFs and manning levels as well as studying associations between SCFs and FEs (**Figure 6**).
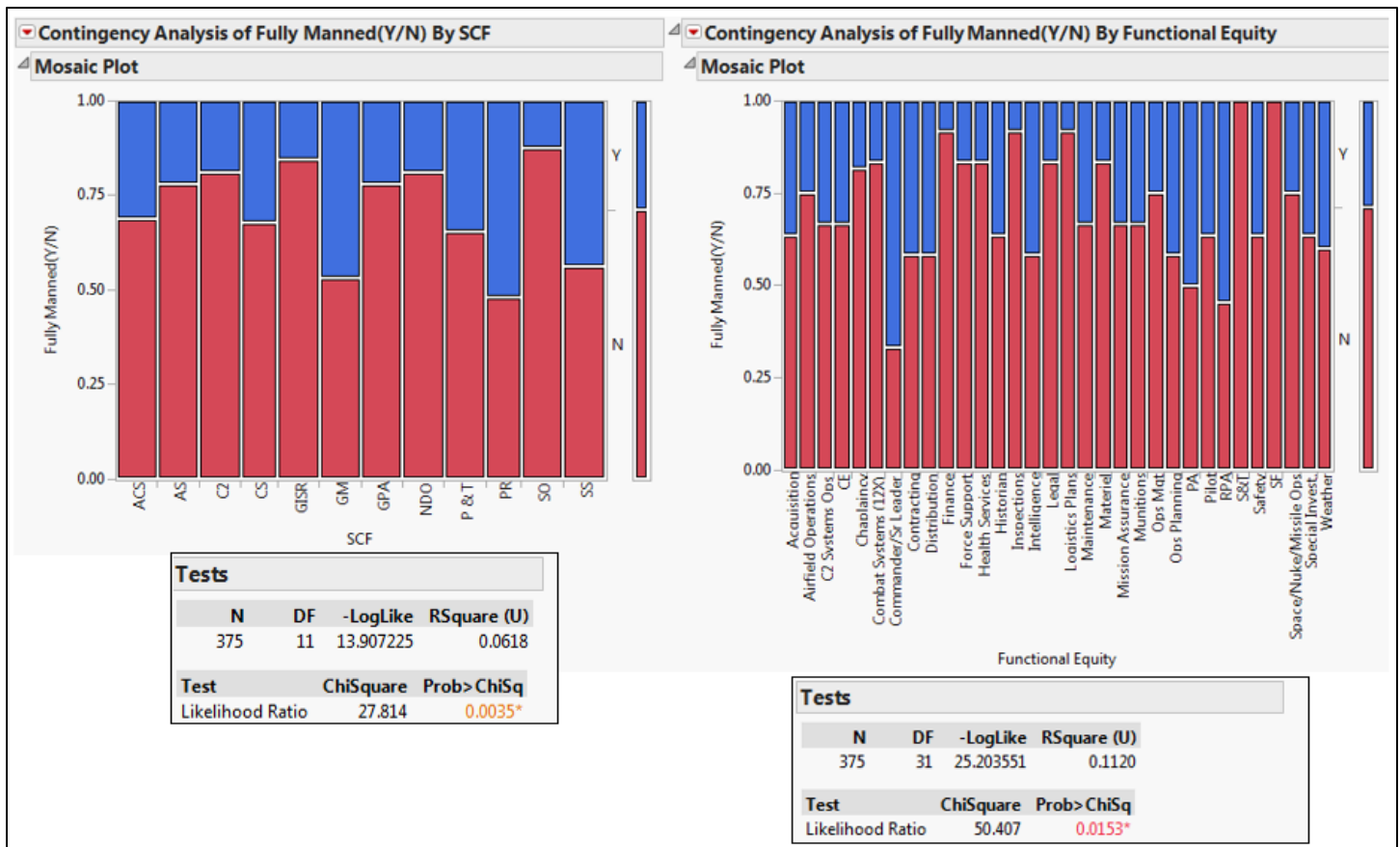
Figure 6: SCF and FE manning Contingency Analysis

Figure 6 via the Likelihood Ratio test statistic shows the chi-square values from the SCF and FE observations, which are 27.814 and 50.507 respectively. Since, the p-value is less than α (0.05) this demonstrates there is a significant association between manning levels and SCF.

The manning categorical variable ('Mann_Cat') is an ordinal response with six levels. We test this response for homogeneity among the SCF and FE variables. Since, the Likelihood ratio p-values are smaller than α, the results of tests suggests the difference in manning levels across SCF and FE are statistically significant (**Figure 7**).
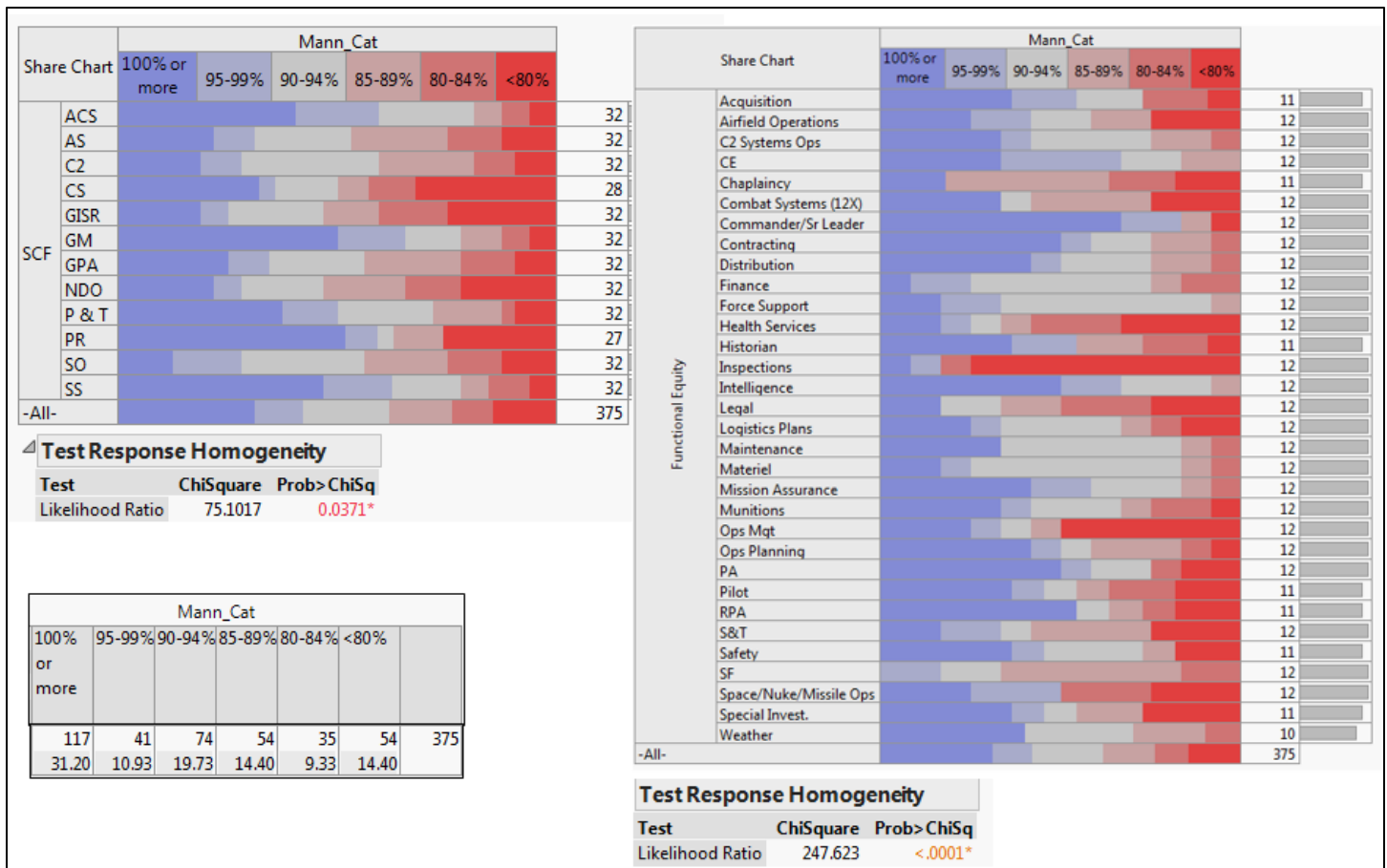
Figure 7: Ordinal Categorical Analysis

Modeling Approach

Although, the focus of this study is to explore not to necessarily predict manning levels among SCFs and FEs, the data are investigated to see if a nominal logistic regression model can provide more meaningful insight among the SCFs and FEs as it relates to being fully manned or not. Logistic regression analysis describes how a binary (0 or 1) response variable is associated with a set of explanatory variables (categorical or continuous). The general logistic function is $\pi(x) = \frac{e^{(\propto + \beta x)}}{1 + e^{(\propto + \beta x)}} = \frac{odds}{1 + odds}$ where x is the independent variable or factor and e is the exponential function, and $\pi(x)$ is the probability of being at least 100% manned. For this nominal outcome variable, each factor is examined individually and associated model statistics are compared to a joint (combined) model. The manning categorical (ordinal) factor is not a statistically significant effect in any of the models as the p-values for the parameter estimates were greater than α. **Figure 8** provides a summary of the results.

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	41.69940	42	83.39879	0.0001*
Full	183.43230		Combined	
Reduced	225.13170			

		Goodness Of Fit Statistic	ChiSquare	DF	Prob>ChiSq
RSquare (U)	0.1852	Pearson	362.3808	332	0.1209
AICc	464.297	Deviance	366.8646	332	0.0911
BIC	621.722				
Observations (or Sum Wgts)	375				

Measure	Training	Definition
Entropy RSquare	0.1852	1-Loglike(model)/Loglike(0)
Generalized RSquare	0.2853	$(1-(L(0)/L(model))^{2/n})/(1-L(0)^{2/n})$
Mean -Log p	0.4892	$\sum -Log(\rho[j])/n$
RMSE	0.4026	$\sqrt{\sum(y[j]-\rho[j])^2/n}$
Mean Abs Dev	0.3253	$\sum |y[j]-\rho[j]|/n$
Misclassification Rate	0.2400	$\sum (\rho[j]\neq\rho Max)/n$
N	375	n

AUC
0.78223

Figure 8: SCF & FE manning Model Comparison

Results from the joint model from the 'Whole Model Test' shows significance. The accuracy rates (1- misclassification rate) regarding predictability classifies success 76% of the time. The Goodness of Fit (GoF) statistic suggest the model is adequate as the Deviance values are above α.   The joint model has an Area under the Curve (AUC) of 0.782. This suggests the modeling predictions have more than a 'chance' of being accurate. In fact, a strict interpretation of this model is that when presented randomly with a given number of SCF and FE manning observations that are ≥ 100% and ≤ 100%, there is a 78.2% chance of correct classification. **Figure 9** depicts the model probability estimates of being 100% or more manned by SCF and FE.
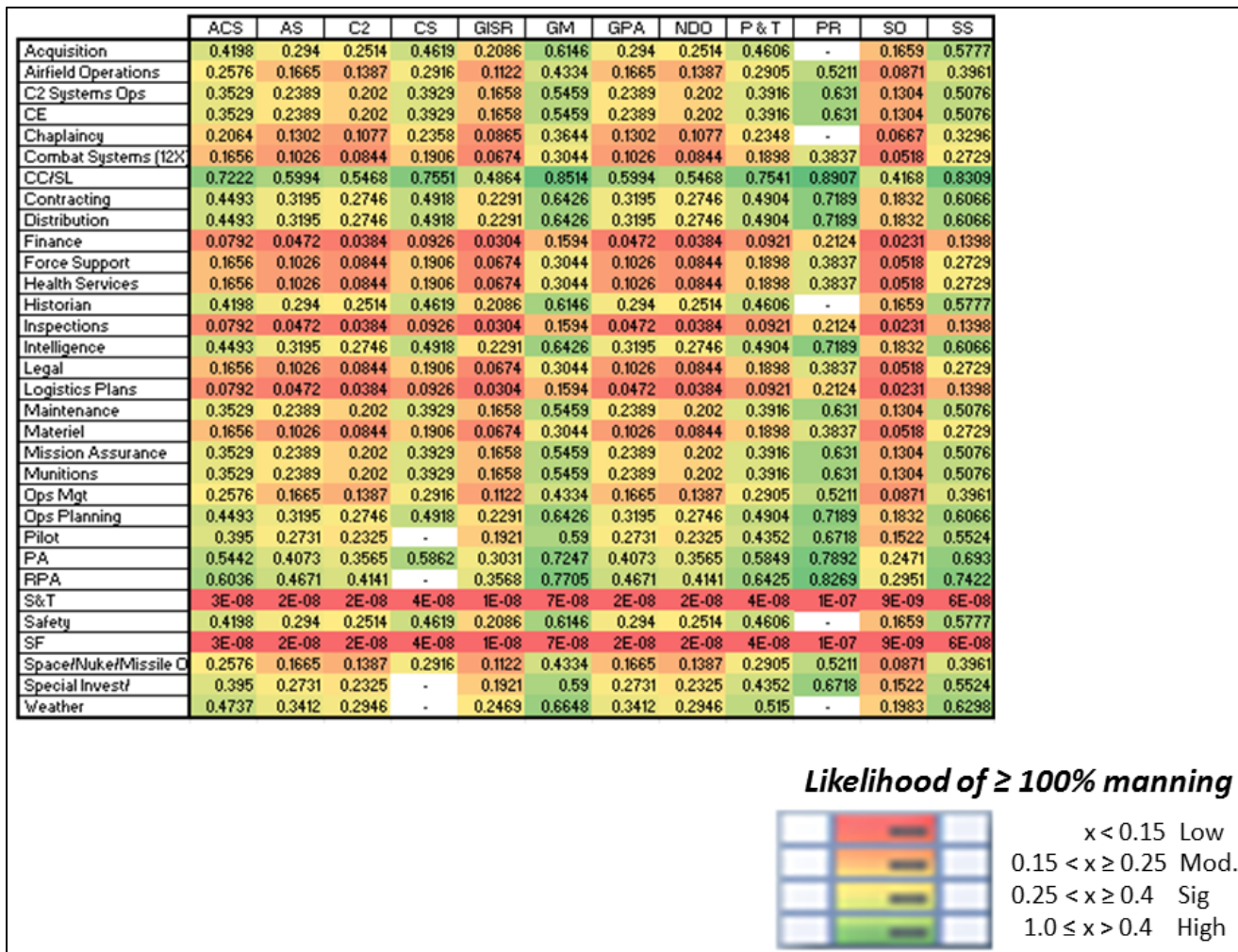
	ACS	AS	C2	CS	GISR	GM	GPA	NDO	P&T	PR	SO	SS
Acquisition	0.4198	0.294	0.2514	0.4619	0.2086	0.6146	0.294	0.2514	0.4606	-	0.1659	0.5777
Airfield Operations	0.2576	0.1665	0.1387	0.2916	0.1122	0.4334	0.1665	0.1387	0.2905	0.5211	0.0871	0.3961
C2 Systems Ops	0.3529	0.2389	0.202	0.3929	0.1658	0.5459	0.2389	0.202	0.3916	0.631	0.1304	0.5076
CE	0.3529	0.2389	0.202	0.3929	0.1658	0.5459	0.2389	0.202	0.3916	0.631	0.1304	0.5076
Chaplaincy	0.2064	0.1302	0.1077	0.2358	0.0865	0.3644	0.1302	0.1077	0.2348	-	0.0667	0.3296
Combat Systems (12X	0.1656	0.1026	0.0844	0.1906	0.0674	0.3044	0.1026	0.0844	0.1898	0.3837	0.0518	0.2729
CC/SL	0.7222	0.5994	0.5468	0.7551	0.4864	0.8514	0.5994	0.5468	0.7541	0.8907	0.4168	0.8309
Contracting	0.4493	0.3195	0.2746	0.4918	0.2291	0.6426	0.3195	0.2746	0.4904	0.7189	0.1832	0.6066
Distribution	0.4493	0.3195	0.2746	0.4918	0.2291	0.6426	0.3195	0.2746	0.4904	0.7189	0.1832	0.6066
Finance	0.0792	0.0472	0.0384	0.0926	0.0304	0.1594	0.0472	0.0384	0.0921	0.2124	0.0231	0.1398
Force Support	0.1656	0.1026	0.0844	0.1906	0.0674	0.3044	0.1026	0.0844	0.1898	0.3837	0.0518	0.2729
Health Services	0.1656	0.1026	0.0844	0.1906	0.0674	0.3044	0.1026	0.0844	0.1898	0.3837	0.0518	0.2729
Historian	0.4198	0.294	0.2514	0.4619	0.2086	0.6146	0.294	0.2514	0.4606	-	0.1659	0.5777
Inspections	0.0792	0.0472	0.0384	0.0926	0.0304	0.1594	0.0472	0.0384	0.0921	0.2124	0.0231	0.1398
Intelligence	0.4493	0.3195	0.2746	0.4918	0.2291	0.6426	0.3195	0.2746	0.4904	0.7189	0.1832	0.6066
Legal	0.1656	0.1026	0.0844	0.1906	0.0674	0.3044	0.1026	0.0844	0.1898	0.3837	0.0518	0.2729
Logistics Plans	0.0792	0.0472	0.0384	0.0926	0.0304	0.1594	0.0472	0.0384	0.0921	0.2124	0.0231	0.1398
Maintenance	0.3529	0.2389	0.202	0.3929	0.1658	0.5459	0.2389	0.202	0.3916	0.631	0.1304	0.5076
Materiel	0.1656	0.1026	0.0844	0.1906	0.0674	0.3044	0.1026	0.0844	0.1898	0.3837	0.0518	0.2729
Mission Assurance	0.3529	0.2389	0.202	0.3929	0.1658	0.5459	0.2389	0.202	0.3916	0.631	0.1304	0.5076
Munitions	0.3529	0.2389	0.202	0.3929	0.1658	0.5459	0.2389	0.202	0.3916	0.631	0.1304	0.5076
Ops Mgt	0.2576	0.1665	0.1387	0.2916	0.1122	0.4334	0.1665	0.1387	0.2905	0.5211	0.0871	0.3961
Ops Planning	0.4493	0.3195	0.2746	0.4918	0.2291	0.6426	0.3195	0.2746	0.4904	0.7189	0.1832	0.6066
Pilot	0.395	0.2731	0.2325	-	0.1921	0.59	0.2731	0.2325	0.4352	0.6718	0.1522	0.5524
PA	0.5442	0.4073	0.3565	0.5862	0.3031	0.7247	0.4073	0.3565	0.5849	0.7892	0.2471	0.693
RPA	0.6036	0.4671	0.4141	-	0.3568	0.7705	0.4671	0.4141	0.6425	0.8269	0.2951	0.7422
S&T	3E-08	2E-08	2E-08	4E-08	1E-08	7E-08	2E-08	2E-08	4E-08	1E-07	9E-09	6E-08
Safety	0.4198	0.294	0.2514	0.4619	0.2086	0.6146	0.294	0.2514	0.4606	-	0.1659	0.5777
SF	3E-08	2E-08	2E-08	4E-08	1E-08	7E-08	2E-08	2E-08	4E-08	1E-07	9E-09	6E-08
Space/Nuke/Missile O	0.2576	0.1665	0.1387	0.2916	0.1122	0.4334	0.1665	0.1387	0.2905	0.5211	0.0871	0.3961
Special Invest/	0.395	0.2731	0.2325	-	0.1921	0.59	0.2731	0.2325	0.4352	0.6718	0.1522	0.5524
Weather	0.4737	0.3412	0.2946	-	0.2469	0.6648	0.3412	0.2946	0.515	-	0.1983	0.6298

Likelihood of ≥ 100% manning

x < 0.15	Low
0.15 < x ≥ 0.25	Mod.
0.25 < x ≥ 0.4	Sig
1.0 ≤ x > 0.4	High

Figure 9: SCF and FE Likelihood being fully manned[2]

The results suggest none of the FEs by SCF are likely to be 100% manned or more. Notably, the Science & Technology (S&T) and Security Forces (SFs) FEs are highly likely to not be fully manned in any SCF or FE. Conversely, the commander or senior leader FEs has the potential in the Global Mobility (GM) and Personnel Recovery (PR) SCFs to have 100% or more manning. This is illustrated via the likelihood color palette scale in Figure 9. Arguably, rows (FEs) in red are highly less likely to be 100% or more manned.

Model Results

Figure 10 is a matrix of the modeling interpretations of the success/failure probabilities of the 375 observations. Probability of Success $\left(\left(\frac{1}{1+e^{logit[\pi(x)]}}\right)\right)$ is considered 100% or more manned or a green 'Y', otherwise a red 'N' in the matrix of cells.

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[2] Cells without values indicate the FE was not represented in the SCF.

	ACS	AS	C2	CS	GISR	GM	GPA	NDO	P & T	PR	SO	SS
Acquisition	N	N	N	N	N	Y	N	N	N	-	N	Y
Airfield Operations	N	N	N	N	N	N	N	N	N	Y	N	N
C2 Systems Ops	N	N	N	N	N	Y	N	N	N	Y	N	Y
CE	N	N	N	N	N	Y	N	N	N	Y	N	Y
Chaplaincy	N	N	N	N	N	N	N	N	N	-	N	N
Combat Systems (12X)	N	N	N	N	N	N	N	N	N	N	N	N
CC/SL	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y
Contracting	N	N	N	N	N	Y	N	N	N	Y	N	Y
Distribution	N	N	N	N	N	Y	N	N	N	Y	N	Y
Finance	N	N	N	N	N	N	N	N	N	N	N	N
Force Support	N	N	N	N	N	N	N	N	N	N	N	N
Health Services	N	N	N	N	N	N	N	N	N	N	N	N
Historian	N	N	N	N	N	Y	N	N	N	-	N	Y
Inspections	N	N	N	N	N	N	N	N	N	N	N	N
Intelligence	N	N	N	N	N	Y	N	N	N	Y	N	Y
Legal	N	N	N	N	N	N	N	N	N	N	N	N
Logistics Plans	N	N	N	N	N	N	N	N	N	N	N	N
Maintenance	N	N	N	N	N	Y	N	N	N	Y	N	Y
Materiel	N	N	N	N	N	N	N	N	N	N	N	N
Mission Assurance	N	N	N	N	N	Y	N	N	N	Y	N	Y
Munitions	N	N	N	N	N	Y	N	N	N	Y	N	Y
Ops Mgt	N	N	N	N	N	N	N	N	N	Y	N	N
Ops Planning	N	N	N	N	N	Y	N	N	N	Y	N	Y
Pilot	N	N	N	-	N	Y	N	N	N	Y	N	Y
PA	Y	N	N	Y	N	Y	N	N	Y	Y	N	Y
RPA	Y	N	N	-	N	Y	N	N	Y	Y	N	Y
S&T	N	N	N	N	N	N	N	N	N	N	N	N
Safety	N	N	N	N	N	Y	N	N	N	-	N	Y
SF	N	N	N	N	N	N	N	N	N	N	N	N
Space/Nuke/Missile Ops	N	N	N	N	N	N	N	N	N	Y	N	N
Special Invest/	N	N	N	-	N	Y	N	N	N	Y	N	Y
Weather	N	N	N	-	N	Y	N	N	Y	-	N	Y

Figure 10: Likelihood of 100% manning in binary form

The full joint model equation is listed in **Appendix I**.

Odds Ratio Analyses

The outcome variable is a success/fail response variable so Odds Ratios (ORs) via logistic transformations (logits) are computed and compared among SCFs and FEs. The logistic odds is represented as $Logit[\pi(x)] = log(odds) = log\left(\frac{\pi(x)}{1-\pi(x)}\right) = \beta_0 + \beta_1 X_1 + \cdots \beta_p X_p$ where β_0 is the intercept, β_p (the parameter) is the log OR of one unit increase in x whereas $e^{(\beta)}$ is the OR of one unit increase in x (Agresti, 2013). The ORs are computed from the joint model previously discussed. A total of 1,034 ($12\,{}^{\mathbf{P}}2 + 32\,{}^{\mathbf{P}}2$) ORs are computed and compared of which 45 (34%) and 160 (16%) are considered 'statistically significantly different than one,' respectively. These overview statistics suggest there are significant differences in full manning levels among SCFs and FEs. **Figure 11** is a matrix of the SCF ORs accompanied with a scale to aid in interpretation.
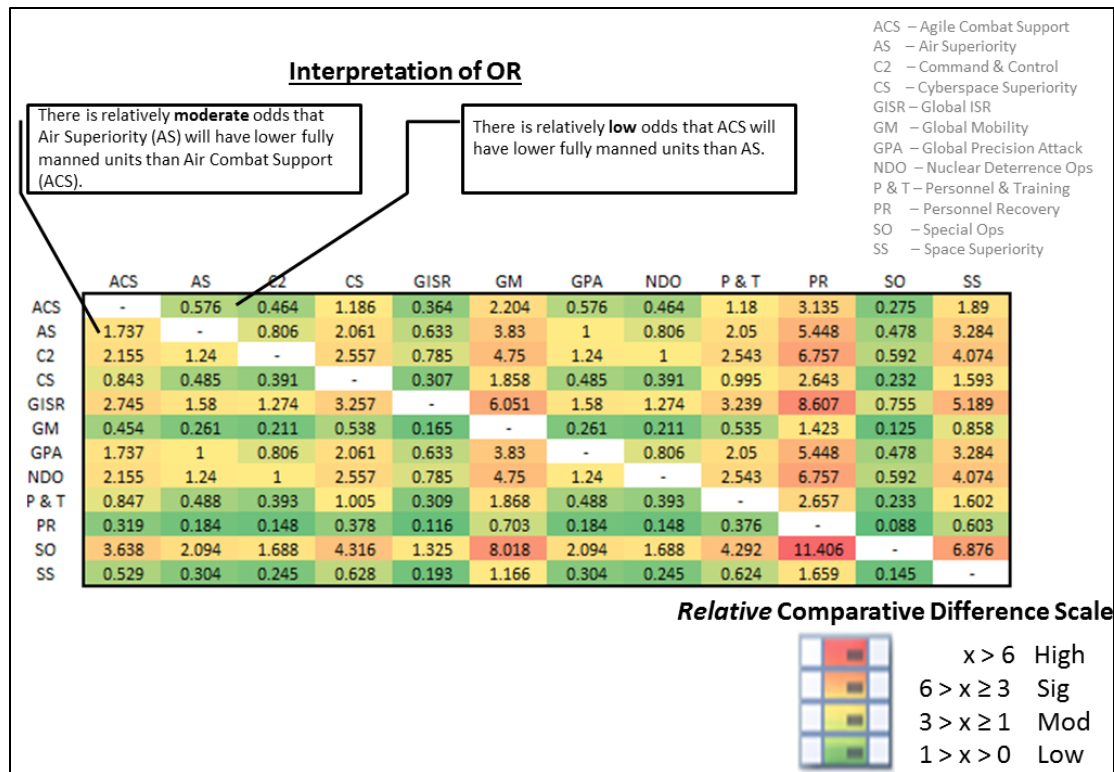
Interpretation of OR

There is relatively **moderate** odds that Air Superiority (AS) will have lower fully manned units than Air Combat Support (ACS).

There is relatively **low** odds that ACS will have lower fully manned units than AS.

ACS – Agile Combat Support
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C2 – Command & Control
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SO – Special Ops
SS – Space Superiority

	ACS	AS	C2	CS	GISR	GM	GPA	NDO	P & T	PR	SO	SS
ACS	-	0.576	0.464	1.186	0.364	2.204	0.576	0.464	1.18	3.135	0.275	1.89
AS	1.737	-	0.806	2.061	0.633	3.83	1	0.806	2.05	5.448	0.478	3.284
C2	2.155	1.24	-	2.557	0.785	4.75	1.24	1	2.543	6.757	0.592	4.074
CS	0.843	0.485	0.391	-	0.307	1.858	0.485	0.391	0.995	2.643	0.232	1.593
GISR	2.745	1.58	1.274	3.257	-	6.051	1.58	1.274	3.239	8.607	0.755	5.189
GM	0.454	0.261	0.211	0.538	0.165	-	0.261	0.211	0.535	1.423	0.125	0.858
GPA	1.737	1	0.806	2.061	0.633	3.83	-	0.806	2.05	5.448	0.478	3.284
NDO	2.155	1.24	1	2.557	0.785	4.75	1.24	-	2.543	6.757	0.592	4.074
P & T	0.847	0.488	0.393	1.005	0.309	1.868	0.488	0.393	-	2.657	0.233	1.602
PR	0.319	0.184	0.148	0.378	0.116	0.703	0.184	0.148	0.376	-	0.088	0.603
SO	3.638	2.094	1.688	4.316	1.325	8.018	2.094	1.688	4.292	11.406	-	6.876
SS	0.529	0.304	0.245	0.628	0.193	1.166	0.304	0.245	0.624	1.659	0.145	-

Relative **Comparative Difference Scale**

$x > 6$	High
$6 > x \geq 3$	Sig
$3 > x \geq 1$	Mod
$1 > x > 0$	Low

Figure 11: SCF OR Comparison

The matrix should be examined from left to right by row. For example, the Air Superiority (AS) SCF compared to the Agile Combat Support (ACS) SCF has 0.576, or low odds, of being fully manned. Conversely, ACS has 1.737 odds, or moderate odds, of being fully manned when compared to AS. The top 3 SCFs with better odds of full manning levels are Personnel Recovery, Global Mobility and Space Superiority. This is fairly intuitive as these rows are more green. The bottom 4 SCFs with lesser odds of full manning levels are Command & Control, Nuclear Deterrence Options, Global ISR and Special Operations. Further, the same matrix from Figure 11 overlaid with turquoise outlines is used in **Figure 12** to illustrate which SCF ORs are considered significantly different. Similar analysis is performed by FE. The FE results are listed in **Appendices III and IV**.

	ACS	AS	C2	CS	GISR	GM	GPA	NDO	P & T	PR	SO	SS	Comparisons	Total OR
ACS	-	0.576	0.464	1.186	0.364	2.204	0.576	0.464	1.18	3.135	0.275	1.89	61	12.314
AS	1.737	-	0.806	2.061	0.633	3.83	1	0.806	2.05	5.448	0.478	3.284	60	22.133
C2	2.155	1.24	-	2.557	0.785	4.75	1.24	1	2.543	6.757	0.592	4.074	80	27.693
CS	0.843	0.485	0.391	-	0.307	1.858	0.485	0.391	0.995	2.643	0.232	1.593	40	10.223
GISR	2.745	1.58	1.274	3.257	-	6.051	1.58	1.274	3.239	8.607	0.755	5.189	100	35.551
GM	0.454	0.261	0.211	0.538	0.165	-	0.261	0.211	0.535	1.423	0.125	0.858	10	5.042
GPA	1.737	1	0.806	2.061	0.633	3.83	-	0.806	2.05	5.448	0.478	3.284	60	22.133
NDO	2.155	1.24	1	2.557	0.785	4.75	1.24	-	2.543	6.757	0.592	4.074	80	27.693
P & T	0.847	0.488	0.393	1.005	0.309	1.868	0.488	0.393	-	2.657	0.233	1.602	30	10.283
PR	0.319	0.184	0.148	0.378	0.116	0.703	0.184	0.148	0.376	-	0.088	0.603	0	3.247
SO	3.638	2.094	1.688	4.316	1.325	8.018	2.094	1.688	4.292	11.406	-	6.876	110	47.435
SS	0.529	0.304	0.245	0.628	0.193	1.166	0.304	0.245	0.624	1.659	0.145	-	20	6.042

Considered Statistically Different

Figure 12: SCF OR Comparison with Significance Indicators

Figure 12's results reveal the Global Mobility, Personnel Recovery and Space Superiority SCFs have statistically different manning levels as it relates to being fully manned or not.

Relative Risk

Relative risk ratios (RRR) which are comparative ratios of the probabilities of success (i.e. a given SCF and FE being fully manned) is another quantitative way to compare categories. As the number of categorical levels increases, the number of relative comparisons grows quite large. For example, 12 SCF and FE RRR one-way comparisons is 4,224 ($12 \, P \, 2$ combinations *32 FEs) possibilities. In this instance, we will only explore relative comparisons to the ACS SCF. The probabilities of success are taken from the joint model results depicted in Figure 9. If the RRR is equal to 1, we conclude independence or FE_1 with respect to a given SCF is neither more likely nor less likely of occurring than FE_2 with respect to the same SCF. If the RRR is less than 1, we conclude FE_1 with respect to a given SCF is less likely of occurring than FE_2 with respect to the same SCF. If the RRR is greater than 1, we conclude FE_1 with respect to a given SCF is more likely of occurring than FE_2 with respect to the same SCF. The RRRs are computed and shown in **Figure 13**.

	ACS	AS	C2	CS	GISR	GM	GPA	NDO	P & T	PR	SO	SS
Acquisition	1	1.43	1.67	0.91	2.01	0.68	1.43	1.67	0.91	-	2.53	0.73
Airfield Operations	1.63	1.55	1.86	0.88	2.3	0.59	1.55	1.86	0.89	0.49	2.96	0.65
C2 Systems Ops	1.19	1.48	1.75	0.9	2.13	0.65	1.48	1.75	0.9	0.56	2.71	0.7
CE	1.19	1.48	1.75	0.9	2.13	0.65	1.48	1.75	0.9	0.56	2.71	0.7
Chaplaincy	2.03	1.59	1.92	0.88	2.38	0.57	1.59	1.92	0.88	-	3.09	0.63
Combat Systems (12X)	2.53	1.62	1.96	0.87	2.46	0.54	1.62	1.96	0.87	0.43	3.2	0.61
CC/SL	0.58	1.2	1.32	0.96	1.48	0.85	1.2	1.32	0.96	0.81	1.73	0.87
Contracting	0.93	1.41	1.64	0.91	1.96	0.7	1.41	1.64	0.92	0.62	2.45	0.74
Distribution	0.93	1.41	1.64	0.91	1.96	0.7	1.41	1.64	0.92	0.62	2.45	0.74
Finance	5.3	1.68	2.06	0.86	2.61	0.5	1.68	2.06	0.86	0.37	3.43	0.57
Force Support	2.53	1.62	1.96	0.87	2.46	0.54	1.62	1.96	0.87	0.43	3.2	0.61
Health Services	2.53	1.62	1.96	0.87	2.46	0.54	1.62	1.96	0.87	0.43	3.2	0.61
Historian	1	1.43	1.67	0.91	2.01	0.68	1.43	1.67	0.91	-	2.53	0.73
Inspections	5.3	1.68	2.06	0.86	2.61	0.5	1.68	2.06	0.86	0.37	3.43	0.57
Intelligence	0.93	1.41	1.64	0.91	1.96	0.7	1.41	1.64	0.92	0.62	2.45	0.74
Legal	2.53	1.62	1.96	0.87	2.46	0.54	1.62	1.96	0.87	0.43	3.2	0.61
Logistics Plans	5.3	1.68	2.06	0.86	2.61	0.5	1.68	2.06	0.86	0.37	3.43	0.57
Maintenance	1.19	1.48	1.75	0.9	2.13	0.65	1.48	1.75	0.9	0.56	2.71	0.7
Materiel	2.53	1.62	1.96	0.87	2.46	0.54	1.62	1.96	0.87	0.43	3.2	0.61
Mission Assurance	1.19	1.48	1.75	0.9	2.13	0.65	1.48	1.75	0.9	0.56	2.71	0.7
Munitions	1.19	1.48	1.75	0.9	2.13	0.65	1.48	1.75	0.9	0.56	2.71	0.7
Ops Mgt	1.63	1.55	1.86	0.88	2.3	0.59	1.55	1.86	0.89	0.49	2.96	0.65
Ops Planning	0.93	1.41	1.64	0.91	1.96	0.7	1.41	1.64	0.92	0.62	2.45	0.74
Pilot	1.06	1.45	1.7	-	2.06	0.67	1.45	1.7	0.91	0.59	2.6	0.72
PA	0.77	1.34	1.53	0.93	1.8	0.75	1.34	1.53	0.93	0.69	2.2	0.79
RPA	0.7	1.29	1.46	-	1.69	0.78	1.29	1.46	0.94	0.73	2.05	0.81
S&T	1E+07	1.74	2.16	0.84	2.75	0.45	1.74	2.16	0.85	0.32	3.64	0.53
Safety	1	1.43	1.67	0.91	2.01	0.68	1.43	1.67	0.91	-	2.53	0.73
SF	1E+07	1.74	2.16	0.84	2.75	0.45	1.74	2.16	0.85	0.32	3.64	0.53
Space/Nuke/Missile Ops	1.63	1.55	1.86	0.88	2.3	0.59	1.55	1.86	0.89	0.49	2.96	0.65
Special Invest/	1.06	1.45	1.7	-	2.06	0.67	1.45	1.7	0.91	0.59	2.6	0.72
Weather	0.89	1.39	1.61	-	1.92	0.71	1.39	1.61	0.92	-	2.39	0.75

Figure 13: SCF/FE Relative Risk Ratio table

In the ACS column of Figure 13, the Acquisition FE is held fixed compared to the other FEs within the ACS SCF. If we refer to the Airfield Operations and Acquisition FEs within the ACS SCF, we see a RRR of 1.63. The interpretation is within the ACS SCF, the Acquisition FE is 1.63 times likely of being 100% or more manned than Airfield Operations. For the rest of the columns (AS-SS), the RRRs are compared within each row or the FE is held fixed relative to the ACS SCF. For example, the 1.43 RRR at the intersection of the Acquisition FE and AS SCF, infers within the Acquisitions FE, the Air Combat Support SCF is 1.43 times likely of being 100% or more manned than the Air Superiority SCF. Similarly, at the intersection of the Acquisition FE and C2 SCF, infers within the Acquisitions FE, the Air Combat Support SCF is 1.67 times likely of being 100% or more manned than the Command and Control SCF. A takeaway from Figure 13 is ACS has a relative moderate risk to the other SCFs with regards to being 100% or more manned.

SCF and FE Prioritization

Strategic Decision Makers need a concise way to prioritize SCF and FE manning groups.   One way is to rank them by level of manning deficiencies. Computing the odds ratios from the logits and examining the odds between SCFs and FEs affords a quantitative opportunity to assess, compare and establish a ranking. There are several methods.

The first ranking method is to compare the values of the ORs of a given SCF to all of the other SCF ORs in the population. For example, ACS' ORs would be compared to the other 11 SCF ORs. We compare them by summing the count of all ACS ORs *not* greater than the other 11 SCF ORs.   From the computed analysis, we know this value to be 61. This means out of the 121 possibilities for ACS ORs to be less than the other SCFs, ACS has lesser manning odds than about half of the other SCFs. We apply this technique across all SCFs and obtain a list ranked from least to greatest. The SCF with the greatest number of counts is ranked last. From Figure 12, Special Ops (SO) is ranked last and Personnel Recovery is ranked first. The same technique is applied to the FEs.

The second ranking method is to simply compare the size or magnitude of the OR of a given SCF to all of the other SCF ORs in the population. We do this by summing the ORs of each SCF by row and obtain a list ranked from least to greatest. For example, the sum of the ACS' ORs is 12.314. The SCFs with the greatest and least values are ranked last and first respectively.   The same technique is applied to the FEs.

The third ranking method takes into account the amount of shortages and overages of a given SCF or FE. **Table 2** provides a list the overages and shortages by SCF and FE.

Table 2: SCF and FE Overages and Shortages (-)

	Ovg/Sht(-)
ACS	-32
AS	-2076
C2	-674
CS	-1136
GISR	-1363
GM	1519
GPA	-5320
NDO	-1995
P & T	-1828
PR	23
SO	-683
SS	-1146

	Ovg/Sht(-)
Acquisition	-573
Airfield Operations	45
C2 Systems Ops	747
CE	-374
Chaplaincy	-94
Combat Systems (12X)	-250
CC/SL	105
Contracting	-31
Distribution	-983
Finance	9
Force Support	1725
Health Services	678
Historian	-14
Inspections	-87
Intelligence	-442
Legal	-311
Logistics Plans	-71
Maintenance	2189
Materiel	-461
Mission Assurance	220
Munitions	-1234
Ops Mgt	-41
Ops Planning	-476
Pilot	-379
PA	43
RPA	-184
S&T	-550
Safety	44
SF	-1369
Space/Nuke/Missile Ops	-79
Special Invest/	-195
Weather	-41

The overages/shortages are ranked from greatest to least. For example, the PR SCF is ranked first since it has the highest number of overages. Conversely, Global Precision Attack (GPA) is ranked last because it has the highest number of shortages.

The issue with the first three methods is rank ties are common. A way to minimize rank ties is to apply a composition technique. The fourth method is a composite of the first three methods with some additional computations. The composite method involves three components; summing the first three methods' rankings; computing a dampening factor which takes into account the actual manning rate; and computing a weight by accounting for the number of authorizations per SCF or FE. This method is called the composite value denoted by $\beta * \omega * \tau$ where $\beta = 1 + (1 - M)$ represents the dampening factor which M is the manning rate; $\omega = 1 + (\frac{\#\ of\ auths\ per\ SCF\ or\ FE}{Total\ auths})$ and

$$\tau = \sum ith\ Rank(j), \quad where\ i = SCF\ or\ FE\ and\ j = 1,...3.$$

This procedure takes into account the size of the population (SCF or FE), population manning rate, population overage/shortage and population odds of being fully manned. The composite values are then ranked from least to greatest. **Figure 14** shows the final ranked SCFs with regards to the least likely to be fully manned.

ACS – Agile Combat Support
AS – Air Superiority
C2 – Command & Control
CS – Cyberspace Superiority
GISR – Global ISR
GM – Global Mobility
GPA – Global Precision Attack
NDO – Nuclear Deterrence Ops
P & T – Personnel & Training
PR – Personnel Recovery
SO – Special Ops
SS – Space Super

Comp. Value	Ovg/Sht(-)	M Manning	β Dampening Factor	ω Weight	τ Total
23.4647	-32	0.9998	1.0002	1.38	17.00
27.7906	-2076	0.8972	1.1028	1.05	24.00
23.86	-674	0.9671	1.0329	1.05	22.00
16.8776	-1136	0.9076	1.0924	1.03	15.00
33.6074	-1363	0.9331	1.0669	1.05	30.00
5.42472	1519	1.0313	0.9687	1.12	5.00
31.0992	-5320	0.9088	1.0912	1.14	25.00
32.0128	-1995	0.9214	1.0786	1.06	28.00
20.5377	-1828	0.9236	1.0764	1.06	18.00
4.01738	23	1.0056	0.9944	1.01	4.00
31.7578	-683	0.9368	1.0632	1.03	29.00
14.5435	-1146	0.9243	1.0757	1.04	13.00

	ACS	AS	C2	CS	GISR	GM	GPA	NDO	P & T	PR	SO	SS	RANK
ACS	·	0.576	0.464	1.186	0.364	2.204	0.576	0.464	1.18	3.135	0.275	1.89	6
AS	1.737	·	0.806	2.061	0.633	3.83	1	0.806	2.05	5.448	0.478	3.284	8
C2	2.155	1.24	·	2.557	0.785	4.75	1.24	1	2.543	6.757	0.592	4.074	7
CS	0.843	0.485	0.391	·	0.307	1.858	0.485	0.391	0.995	2.643	0.232	1.593	4
GISR	2.745	1.58	1.274	3.257	·	6.051	1.58	1.274	3.239	8.607	0.755	5.189	12
GM	0.454	0.261	0.211	0.538	0.165	·	0.261	0.211	0.535	1.423	0.125	0.858	2
GPA	1.737	1	0.806	2.061	0.633	3.83	·	0.806	2.05	5.448	0.478	3.284	9
NDO	2.155	1.24	1	2.557	0.785	4.75	1.24	·	2.543	6.757	0.592	4.074	11
P & T	0.847	0.488	0.393	1.005	0.309	1.868	0.488	0.393	·	2.657	0.233	1.602	5
PR	0.319	0.184	0.148	0.378	0.116	0.703	0.184	0.148	0.376	·	0.088	0.603	1
SO	3.638	2.094	1.688	4.316	1.325	8.018	2.094	1.688	4.292	11.406	·	6.876	10
SS	0.529	0.304	0.245	0.628	0.193	1.166	0.304	0.245	0.624	1.659	0.145	·	3

Figure 14: SCF Prioritization Technique

Results from Figure 13 show the top 3 SCFs with lower odds of not being fully manned are Personnel Recovery, Global Mobility and Space Superiority. Conversely, the bottom 3 SCFs with higher odds of not being fully manned are Global ISR, Nuclear Deterrence Ops and Special Ops. A comparison of the ranking methods is listed in **Table 3**.

Table 3: Ranking methodology Comparison with respect to being not fully manned

	OR Comp. Rank1	Sum OR Rank2	Ovg/Sht Rank3	Composite Rank4
ACS	8	6	3	6
AS	6	7	11	8
C2	9	9	4	7
CS	5	4	6	4
GISR	11	11	8	12
GM	2	2	1	2
GPA	6	7	12	9
NDO	9	9	10	11
P & T	4	5	9	5
PR	1	1	2	1
SO	12	12	5	10
SS	3	3	7	3

Final Remarks

This research presents an alternative method of assessing USAF manning by SCF and FE by using logistic regression functions and contingency analyses. Statistically, there is an association between SCFs or FEs and full manning levels. Manning relationships among CFLs or FEs can be rigorously prioritized by OR comparisons. Further, this research can inform Strategic Decision Makers of manning capability gaps and substantiate advocacy for more resources to meet combat and peacetime requirements. There are no SCFs fully manned in the USAF. Overall, across the USAF, 'commanders or senior leaders' is the only FE of 32 likely to be fully manned. This methodology enables senior decision makers to better qualify risk and enhance the strategic planning & programming process risk assessment, which enables the CSAF to better substantiate and advocate for personnel resources.

References

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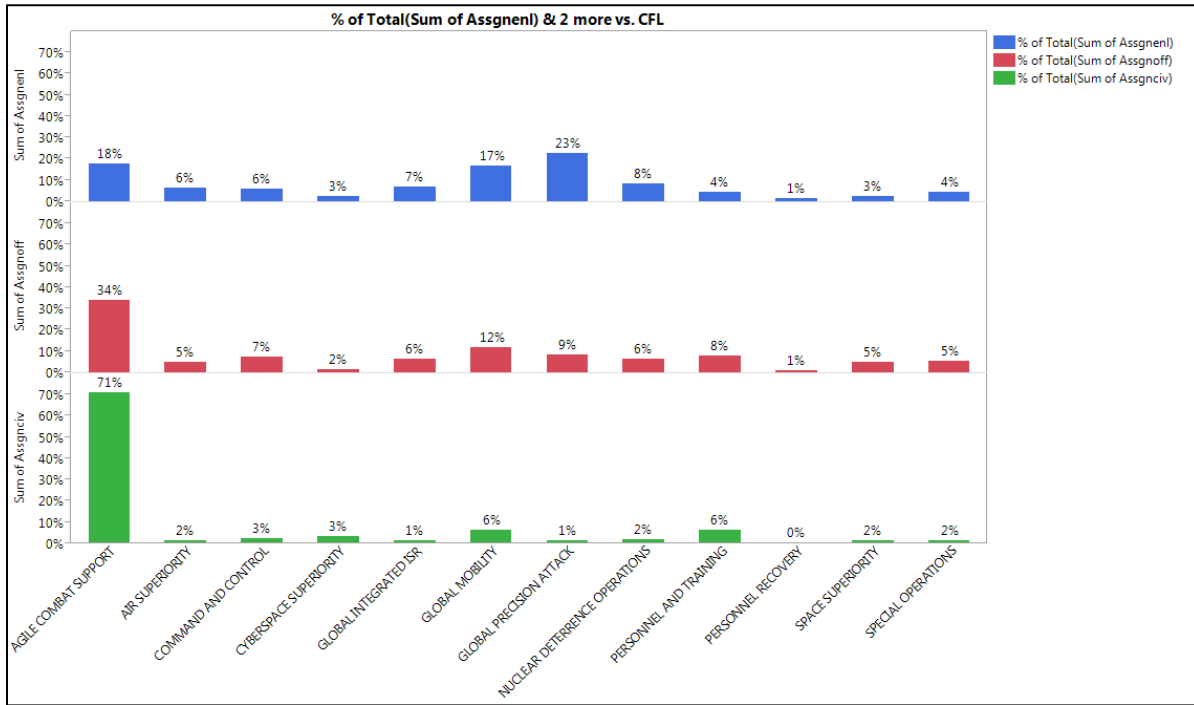
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-There are no DOIs associated with these references.

Appendix I. (Joint Model)

$2.00205380064806 + Match(:\mathbf{\textit{SCF}},$

$\quad "ACS", -0.169625541949248, "AS", 0.382773594328361, "C2", 0.598187339531182, "CS", -0.340458443926399,$

$\quad "GISR", 0.840216482139152, "GM", -0.959983538960857, "GPA", 0.382773594328361,$

$\quad "NDO", 0.598187339531182,$

$"P\&T", -0.335101203204821, "PR", -1.3124077302221, "SO", 1.1217617567933, "SS", -0.806323648388117) +$
$\quad Match(:\mathbf{\textit{Functional\ Equity}},$
$\quad "Acquisition", -1.50895901227517, "Airfield\ Operations", -0.774050445307, "C2\ Systems\ Ops",$

$-1.22630715465715, "CE", -1.22630715465715, "Chaplaincy", -0.485653424612526, "Combat\ Systems\ (12X)",$

$\quad -0.215625028117114, "Commander/Sr\ Leader", -2.78780240085377, "Contracting", -1.6287434114286,$

$"Distribution", -1.6287434114286, "Finance", 0.620987265633101, "Force\ Support", -0.215625028117114,$

$"Health\ Services", -0.215625028117114, "Historian", -1.50895901227517, "Inspections", 0.620987265633101,$

$\quad "Intelligence", -1.6287434114286, "Legal", -0.215625028117114, "Logistics\ Plans", 0.620987265633102,$

$\quad "Maintenance", -1.22630715465715, "Materiel", -0.215625028117114, "Mission\ Assurance",$

$\quad -1.22630715465715, "Munitions", -1.22630715465715, "Ops\ Mgt", -0.774050445307, "Ops\ Planning",$

$\quad -1.6287434114286, "PA", -2.00975916866181, "Pilot", -1.40608660852006, "RPA", -2.25311850963814,$

$\quad "S\&T", 15.3930762469828, "Safety", -1.50895901227517, "SF", 15.3930762472812,$

$\quad "Space/Nuke/Missile\ Ops", -0.774050445307, "Special\ Invest.", -1.40608660852006,$

$\quad "Weather", -1.72694463802467).$

# Appendix II. (SCF and FE Assigned Manning levels by Demographic)

Appendix Figure 1

$$\% \ of \ Total = \frac{Sum \ of \ Assigned \ of \ Demographic \ Functional \ Area}{Total \ Assigned \ of \ Functional \ Area}$$
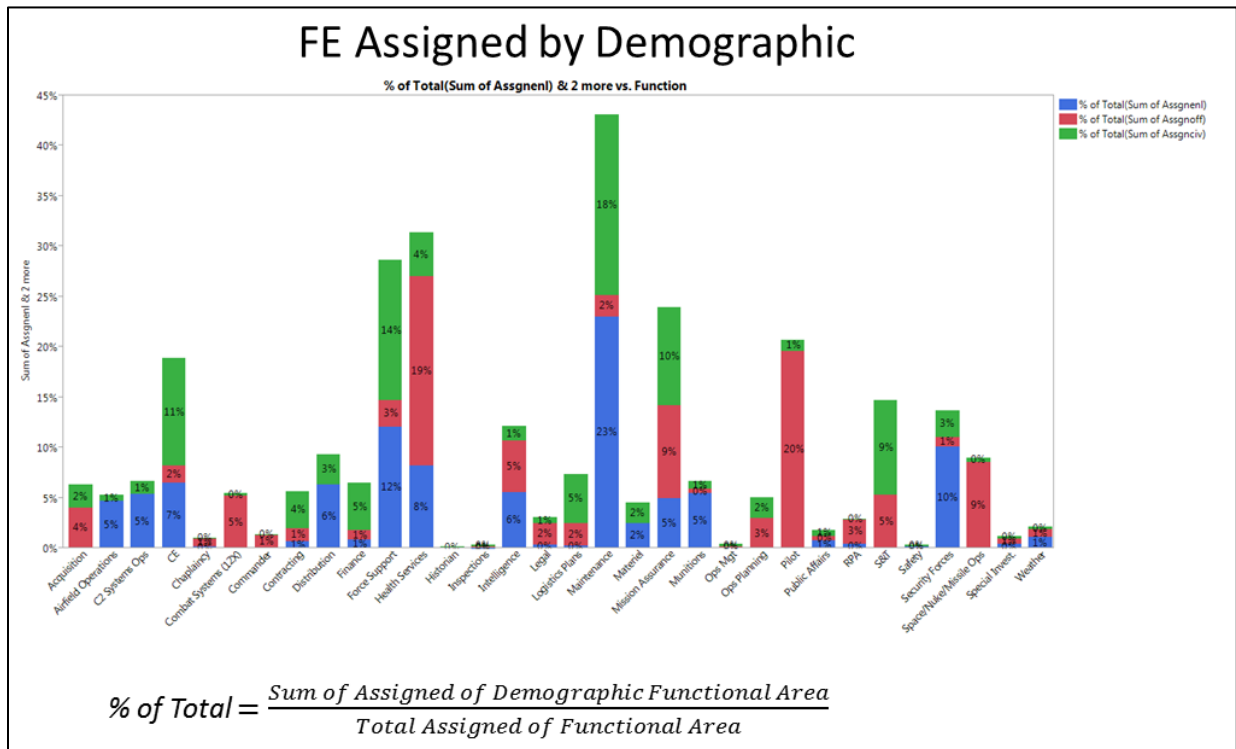
Appendix Figure 2

Appendix III. FE Manning OR Analyses

Rank		Acq	Airfld Op	C2 Sys O	CE	Chap.	Navs	CC/SL	Contr.	Dist.	Fin.	Force Su	Health Sr	Hist.	Insp.	Intel.	LE	LG Plans	Mx	Mat'l	Msn Ass	Muns	Ops Mg	Ops Plan	Pilot	PA	RPA	S&T	SE	SF	e/Nuke	SI	Wx
19	Acq	-	0.48	0.754	0.754	0.359	0.274	3.592	1.127	1.127	0.119	0.274	0.274	1	0.119	1.127	0.274	0.119	0.754	0.274	0.754	0.754	0.48	1.127	0.902	1.65	2.105	0	1	0	0.48	0.902	1.244
14	Airfld Ops	2.085	-	1.572	1.572	0.749	0.572	7.491	2.351	2.351	0.248	0.572	0.572	2.085	0.248	2.351	0.572	0.248	1.572	0.572	1.572	1.572	1	2.351	1.881	3.441	4.389	0	2.085	0	1	1.881	2.593
7	C2 Sys Ops	1.327	0.64	-	1	0.477	0.364	4.766	1.495	1.495	0.158	0.364	0.364	1.327	0.158	1.495	0.364	0.158	1	0.364	1	1	0.636	1.495	1.197	2.189	2.792	0	1.327	0	0.636	1.197	1.65
21	CE	1.327	0.64	1	-	0.477	0.364	4.766	1.495	1.495	0.158	0.364	0.364	1.327	0.158	1.495	0.364	0.158	1	0.364	1	1	0.636	1.495	1.197	2.189	2.792	0	1.327	0	0.636	1.197	1.65
25	Chap.	2.782	1.33	2.097	2.097	-	0.763	9.996	3.136	3.136	0.331	0.763	0.763	2.782	0.331	3.136	0.763	0.331	2.097	0.763	2.097	2.097	1.334	3.136	2.51	4.591	5.856	0	2.782	0	1.334	2.51	3.46
26	Navs	3.645	1.75	2.747	2.747	1.31	-	13.09	4.109	4.109	0.433	1	1	3.645	0.433	4.109	1	0.433	2.747	1	2.747	2.747	1.748	4.109	3.289	6.014	7.671	0	3.645	0	1.748	3.289	4.533
1	CC/SL	0.278	0.13	0.21	0.21	0.1	0.076	-	0.314	0.314	0.033	0.076	0.076	0.278	0.033	0.314	0.076	0.033	0.21	0.076	0.21	0.21	0.133	0.314	0.251	0.459	0.586	0	0.278	0	0.133	0.251	0.346
4	Contr.	0.887	0.43	0.669	0.669	0.319	0.243	3.187	-	1	0.105	0.243	0.243	0.887	0.105	1	0.243	0.105	0.669	0.243	0.669	0.669	0.425	1	0.8	1.464	1.867	0	0.887	0	0.425	0.8	1.103
13	Dist.	0.887	0.43	0.669	0.669	0.319	0.243	3.187	1	-	0.105	0.243	0.243	0.887	0.105	1	0.243	0.105	0.669	0.243	0.669	0.669	0.425	1	0.8	1.464	1.867	0	0.887	0	0.425	0.8	1.103
24	Fin.	8.414	4.04	6.343	6.343	3.024	2.309	30.23	9.485	9.485	-	2.309	2.309	8.414	1	9.485	2.309	1	6.343	2.309	6.343	6.343	4.035	9.485	7.592	13.88	17.71	0	8.414	0	4.035	7.592	10.46
17	Force Supt	3.645	1.75	2.747	2.747	1.31	1	13.09	4.109	4.109	0.433	-	1	3.645	0.433	4.109	1	0.433	2.747	1	2.747	2.747	1.748	4.109	3.289	6.014	7.671	0	3.645	0	1.748	3.289	4.533
18	Health Srvs	3.645	1.75	2.747	2.747	1.31	1	13.09	4.109	4.109	0.433	1	-	3.645	0.433	4.109	1	0.433	2.747	1	2.747	2.747	1.748	4.109	3.289	6.014	7.671	0	3.645	0	1.748	3.289	4.533
8	Hist.	1	0.48	0.754	0.754	0.359	0.274	3.592	1.127	1.127	0.119	0.274	0.274	-	0.119	1.127	0.274	0.119	0.754	0.274	0.754	0.754	0.48	1.127	0.902	1.65	2.105	0	1	0	0.48	0.902	1.244
30	Insp.	8.414	4.04	6.343	6.343	3.024	2.309	30.23	9.485	9.485	1	2.309	2.309	8.414	-	9.485	2.309	1	6.343	2.309	6.343	6.343	4.035	9.485	7.592	13.88	17.71	0	8.414	0	4.035	7.592	10.46
11	Intel.	0.887	0.43	0.669	0.669	0.319	0.243	3.187	1	1	0.105	0.243	0.243	0.887	0.105	-	0.243	0.105	0.669	0.243	0.669	0.669	0.425	1	0.8	1.464	1.867	0	0.887	0	0.425	0.8	1.103
28	LE	3.645	1.75	2.747	2.747	1.31	1	13.09	4.109	4.109	0.433	1	1	3.645	0.433	4.109	-	0.433	2.747	1	2.747	2.747	1.748	4.109	3.289	6.014	7.671	0	3.645	0	1.748	3.289	4.533
27	LG Plans	8.414	4.04	6.343	6.343	3.024	2.309	30.23	9.485	9.485	1	2.309	2.309	8.414	1	9.485	2.309	-	6.343	2.309	6.343	6.343	4.035	9.485	7.592	13.88	17.71	0	8.414	0	4.035	7.592	10.46
9	Mx	1.327	0.64	1	1	0.477	0.364	4.766	1.495	1.495	0.158	0.364	0.364	1.327	0.158	1.495	0.364	0.158	-	0.364	1	1	0.636	1.495	1.197	2.189	2.792	0	1.327	0	0.636	1.197	1.65
29	Mat'l	3.645	1.75	2.747	2.747	1.31	1	13.09	4.109	4.109	0.433	1	1	3.645	0.433	4.109	1	0.433	2.747	-	2.747	2.747	1.748	4.109	3.289	6.014	7.671	0	3.645	0	1.748	3.289	4.533
10	Msn Assr.	1.327	0.64	1	1	0.477	0.364	4.766	1.495	1.495	0.158	0.364	0.364	1.327	0.158	1.495	0.364	0.158	1	0.364	-	1	0.636	1.495	1.197	2.189	2.792	0	1.327	0	0.636	1.197	1.65
23	Muns	1.327	0.64	1	1	0.477	0.364	4.766	1.495	1.495	0.158	0.364	0.364	1.327	0.158	1.495	0.364	0.158	1	0.364	1	-	0.636	1.495	1.197	2.189	2.792	0	1.327	0	0.636	1.197	1.65
20	Ops Mgt	2.085	1	1.572	1.572	0.749	0.572	7.491	2.351	2.351	0.248	0.572	0.572	2.085	0.248	2.351	0.572	0.248	1.572	0.572	1.572	1.572	-	2.351	1.881	3.441	4.389	0	2.085	0	1	1.881	2.593
12	Ops Plans	0.887	0.43	0.669	0.669	0.319	0.243	3.187	1	1	0.105	0.243	0.243	0.887	0.105	1	0.243	0.105	0.669	0.243	0.669	0.669	0.425	-	0.8	1.464	1.867	0	0.887	0	0.425	0.8	1.103
15	Pilot	1.108	0.53	0.835	0.835	0.398	0.304	3.982	1.249	1.249	0.132	0.304	0.304	1.108	0.132	1.249	0.304	0.132	0.835	0.304	0.835	0.835	0.532	1.249	-	1.829	2.333	0	1.108	0	0.532	1	1.378
2	PA	0.606	0.29	0.457	0.457	0.218	0.166	2.177	0.683	0.683	0.072	0.166	0.166	0.606	0.072	0.683	0.166	0.072	0.457	0.166	0.457	0.457	0.291	0.683	0.547	-	1.276	0	0.606	0	0.291	0.547	0.754
5	RPA	0.475	0.23	0.358	0.358	0.171	0.13	1.707	0.536	0.536	0.056	0.13	0.13	0.475	0.056	0.536	0.13	0.056	0.358	0.13	0.358	0.358	0.228	0.536	0.429	0.784	-	0	0.475	0	0.228	0.429	0.591
31	S&T	2E+07	1E+07	2E+07	2E+07	8E+06	6E+06	8E+07	2E+07	2E+07	3E+06	6E+06	6E+06	2E+07	3E+06	2E+07	6E+06	3E+06	2E+07	6E+06	2E+07	2E+07	1E+07	2E+07	2E+07	4E+07	5E+07	-	2E+07	1	1E+07	2E+07	3E+07
6	SE	1	0.48	0.754	0.754	0.359	0.274	3.592	1.127	1.127	0.119	0.274	0.274	1	0.119	1.127	0.274	0.119	0.754	0.274	0.754	0.754	0.48	1.127	0.902	1.65	2.105	0	-	0	0.48	0.902	1.244
32	SF	2E+07	1E+07	2E+07	2E+07	8E+06	6E+06	8E+07	2E+07	2E+07	3E+06	6E+06	6E+06	2E+07	3E+06	2E+07	6E+06	3E+06	2E+07	6E+06	2E+07	2E+07	1E+07	2E+07	2E+07	4E+07	5E+07	1	2E+07	-	1E+07	2E+07	3E+07
22	Space/Nuke/M.O.	2.085	1	1.572	1.572	0.749	0.572	7.491	2.351	2.351	0.248	0.572	0.572	2.085	0.248	2.351	0.572	0.248	1.572	0.572	1.572	1.572	1	2.351	1.881	3.441	4.389	0	2.085	0	-	1.881	2.593
16	SI	1.108	0.53	0.835	0.835	0.398	0.304	3.982	1.249	1.249	0.132	0.304	0.304	1.108	0.132	1.249	0.304	0.132	0.835	0.304	0.835	0.835	0.532	1.249	1	1.829	2.333	0	1.108	0	0.532	-	1.378
3	Wx	0.804	0.39	0.606	0.606	0.289	0.221	2.889	0.906	0.906	0.096	0.221	0.221	0.804	0.096	0.906	0.221	0.096	0.606	0.221	0.606	0.606	0.386	0.906	0.726	1.327	1.692	0	0.804	0	0.386	0.726	-

FE odds of not being fully manned
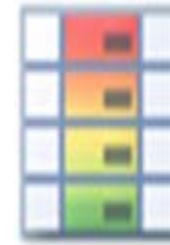
x ≥ 1000	High
1000 > x ≥ 100	Sig
100 > x ≥ 1	Mod
1 > x ≥ 0	Low

Appendix Figure 3

Appendix IV. FE Significant Difference in Manning OR Analyses

	Acq	Airfld Op	C2 Sys O	CE	Chap.	Navs	CC/SL	Contr.	Dist.	Fin.	Force Su	Health Sr	Hist.	Insp.	Intel.	LE	LG Plans	Mx	Mat'l	Msn Ass	Muns	Ops Mg	Ops Plan	Pilot	PA	RPA	S&T	SE	SF	e/Nuke	SI	Wx
Acq	-	0.48	0.754	0.754	0.359	0.274	3.592	1.127	1.127	0.119	0.274	0.274	1	0.119	1.127	0.274	0.119	0.754	0.274	0.754	0.754	0.48	1.127	0.902	1.65	2.105	0	1	0	0.48	0.902	1.244
Airfld Ops	2.085	-	1.572	1.572	0.749	0.572	7.491	2.351	2.351	0.248	0.572	0.572	2.085	0.248	2.351	0.572	0.248	1.572	0.572	1.572	1.572	1	2.351	1.881	3.441	4.389	0	2.085	0	1	1.881	2.593
C2 Sys Ops	1.327	0.64	-	1	0.477	0.364	4.766	1.495	1.495	0.158	0.364	0.364	1.327	0.158	1.495	0.364	0.158	1	0.364	1	1	0.636	1.495	1.197	2.189	2.792	0	1.327	0	0.636	1.197	1.65
CE	1.327	0.64	1	-	0.477	0.364	4.766	1.495	1.495	0.158	0.364	0.364	1.327	0.158	1.495	0.364	0.158	1	0.364	1	1	0.636	1.495	1.197	2.189	2.792	0	1.327	0	0.636	1.197	1.65
Chap.	2.782	1.33	2.097	2.097	-	0.763	9.996	3.136	3.136	0.331	0.763	0.763	2.782	0.331	3.136	0.763	0.331	2.097	0.763	2.097	2.097	1.334	3.136	2.51	4.591	5.856	0	2.782	0	1.334	2.51	3.46
Navs	3.645	1.75	2.747	2.747	1.31	-	13.09	4.109	4.109	0.433	1	1	3.645	0.433	4.109	1	0.433	2.747	1	2.747	2.747	1.748	4.109	3.289	6.014	7.671	0	3.645	0	1.748	3.289	4.533
CC/SL	0.278	0.13	0.21	0.21	0.1	0.076	-	0.314	0.314	0.033	0.076	0.076	0.278	0.033	0.314	0.076	0.033	0.21	0.076	0.21	0.21	0.133	0.314	0.251	0.459	0.586	0	0.278	0	0.133	0.251	0.346
Contr.	0.887	0.43	0.669	0.669	0.319	0.243	3.187	-	1	0.105	0.243	0.243	0.887	0.105	1	0.243	0.105	0.669	0.243	0.669	0.669	0.425	1	0.8	1.464	1.867	0	0.887	0	0.425	0.8	1.103
Dist.	0.887	0.43	0.669	0.669	0.319	0.243	3.187	1	-	0.105	0.243	0.243	0.887	0.105	1	0.243	0.105	0.669	0.243	0.669	0.669	0.425	1	0.8	1.464	1.867	0	0.887	0	0.425	0.8	1.103
Fin.	8.414	4.04	6.343	6.343	3.024	2.309	30.23	9.485	9.485	-	2.309	2.309	8.414	1	9.485	2.309	1	6.343	2.309	6.343	6.343	4.035	9.485	7.592	13.88	17.71	0	8.414	0	4.035	7.592	10.46
Force Supt	3.645	1.75	2.747	2.747	1.31	1	13.09	4.109	4.109	0.433	-	1	3.645	0.433	4.109	1	0.433	2.747	1	2.747	2.747	1.748	4.109	3.289	6.014	7.671	0	3.645	0	1.748	3.289	4.533
Health Srvs	3.645	1.75	2.747	2.747	1.31	1	13.09	4.109	4.109	0.433	1	-	3.645	0.433	4.109	1	0.433	2.747	1	2.747	2.747	1.748	4.109	3.289	6.014	7.671	0	3.645	0	1.748	3.289	4.533
Hist.	1	0.48	0.754	0.754	0.359	0.274	3.592	1.127	1.127	0.119	0.274	0.274	-	0.119	1.127	0.274	0.119	0.754	0.274	0.754	0.754	0.48	1.127	0.902	1.65	2.105	0	1	0	0.48	0.902	1.244
Insp.	8.414	4.04	6.343	6.343	3.024	2.309	30.23	9.485	9.485	1	2.309	2.309	8.414	-	9.485	2.309	1	6.343	2.309	6.343	6.343	4.035	9.485	7.592	13.88	17.71	0	8.414	0	4.035	7.592	10.46
Intel.	0.887	0.43	0.669	0.669	0.319	0.243	3.187	1	1	0.105	0.243	0.243	0.887	0.105	-	0.243	0.105	0.669	0.243	0.669	0.669	0.425	1	0.8	1.464	1.867	0	0.887	0	0.425	0.8	1.103
LE	3.645	1.75	2.747	2.747	1.31	1	13.09	4.109	4.109	0.433	1	1	3.645	0.433	4.109	-	0.433	2.747	1	2.747	2.747	1.748	4.109	3.289	6.014	7.671	0	3.645	0	1.748	3.289	4.533
LG Plans	8.414	4.04	6.343	6.343	3.024	2.309	30.23	9.485	9.485	1	2.309	2.309	8.414	1	9.485	2.309	-	6.343	2.309	6.343	6.343	4.035	9.485	7.592	13.88	17.71	0	8.414	0	4.035	7.592	10.46
Mx	1.327	0.64	1	1	0.477	0.364	4.766	1.495	1.495	0.158	0.364	0.364	1.327	0.158	1.495	0.364	0.158	-	0.364	1	1	0.636	1.495	1.197	2.189	2.792	0	1.327	0	0.636	1.197	1.65
Mat'l	3.645	1.75	2.747	2.747	1.31	1	13.09	4.109	4.109	0.433	1	1	3.645	0.433	4.109	1	0.433	2.747	-	2.747	2.747	1.748	4.109	3.289	6.014	7.671	0	3.645	0	1.748	3.289	4.533
Msn Assr.	1.327	0.64	1	1	0.477	0.364	4.766	1.495	1.495	0.158	0.364	0.364	1.327	0.158	1.495	0.364	0.158	1	0.364	-	1	0.636	1.495	1.197	2.189	2.792	0	1.327	0	0.636	1.197	1.65
Muns	1.327	0.64	1	1	0.477	0.364	4.766	1.495	1.495	0.158	0.364	0.364	1.327	0.158	1.495	0.364	0.158	1	0.364	1	-	0.636	1.495	1.197	2.189	2.792	0	1.327	0	0.636	1.197	1.65
Ops Mgt	2.085	1	1.572	1.572	0.749	0.572	7.491	2.351	2.351	0.248	0.572	0.572	2.085	0.248	2.351	0.572	0.248	1.572	0.572	1.572	1.572	-	2.351	1.881	3.441	4.389	0	2.085	0	1	1.881	2.593
Ops Plans	0.887	0.43	0.669	0.669	0.319	0.243	3.187	1	1	0.105	0.243	0.243	0.887	0.105	1	0.243	0.105	0.669	0.243	0.669	0.669	0.425	-	0.8	1.464	1.867	0	0.887	0	0.425	0.8	1.103
Pilot	1.108	0.53	0.835	0.835	0.398	0.304	3.982	1.249	1.249	0.132	0.304	0.304	1.108	0.132	1.249	0.304	0.132	0.835	0.304	0.835	0.835	0.532	1.249	-	1.829	2.333	0	1.108	0	0.532	1	1.378
PA	0.606	0.29	0.457	0.457	0.218	0.166	2.177	0.683	0.683	0.072	0.166	0.166	0.606	0.072	0.683	0.166	0.072	0.457	0.166	0.457	0.457	0.291	0.683	0.547	-	1.276	0	0.606	0	0.291	0.547	0.754
RPA	0.475	0.23	0.358	0.358	0.171	0.13	1.707	0.536	0.536	0.056	0.13	0.13	0.475	0.056	0.536	0.13	0.056	0.358	0.13	0.358	0.358	0.228	0.536	0.429	0.784	-	0	0.475	0	0.228	0.429	0.591
S&T	2E+07	1E+07	2E+07	2E+07	8E+06	6E+06	8E+07	2E+07	2E+07	3E+06	6E+06	6E+06	2E+07	3E+06	2E+07	6E+06	3E+06	2E+07	6E+06	2E+07	2E+07	1E+07	2E+07	2E+07	4E+07	5E+07	-	2E+07	1	1E+07	2E+07	3E+07
SE	1	0.48	0.754	0.754	0.359	0.274	3.592	1.127	1.127	0.119	0.274	0.274	1	0.119	1.127	0.274	0.119	0.754	0.274	0.754	0.754	0.48	1.127	0.902	1.65	2.105	0	-	0	0.48	0.902	1.244
SF	2E+07	1E+07	2E+07	2E+07	8E+06	6E+06	8E+07	2E+07	2E+07	3E+06	6E+06	6E+06	2E+07	3E+06	2E+07	6E+06	3E+06	2E+07	6E+06	2E+07	2E+07	1E+07	2E+07	2E+07	4E+07	5E+07	1	2E+07	-	1E+07	2E+07	3E+07
Space/Nuke/M.O.	2.085	1	1.572	1.572	0.749	0.572	7.491	2.351	2.351	0.248	0.572	0.572	2.085	0.248	2.351	0.572	0.248	1.572	0.572	1.572	1.572	1	2.351	1.881	3.441	4.389	0	2.085	0	-	1.881	2.593
SI	1.108	0.53	0.835	0.835	0.398	0.304	3.982	1.249	1.249	0.132	0.304	0.304	1.108	0.132	1.249	0.304	0.132	0.835	0.304	0.835	0.835	0.532	1.249	1	1.829	2.333	0	1.108	0	0.532	-	1.378
Wx	0.804	0.39	0.606	0.606	0.289	0.221	2.889	0.906	0.906	0.096	0.221	0.221	0.804	0.096	0.906	0.221	0.096	0.606	0.221	0.606	0.606	0.386	0.906	0.726	1.327	1.692	0	0.804	0	0.386	0.726	-

Appendix Figure 4

Considered statistically different